CHAPTER 4: PROPERTY - BASED VALUATION

Introduction

This chapter presents a benefits-transfer analysis that applies data from hedonic valuation studies to data on housing units near NPL sites to estimate the benefits of all NPL remedial actions for which a Record of Decision (ROD) has been issued through 2004. Hedonic valuation studies are indirect measures in that the values for the environmental (dis)amenity are inferred from data on commodities with many relevant properties (U.S. Environmental Protection Agency 2000, 71, 75, 77-79). In a recent review of a similar analysis, an EPA Science Advisory Board (SAB) review panel noted:

> If this approach is utilized, the issues of property value changes and welfare, amenity effects on property values, and benefits transfer need to be addressed. But given the problems with the other approaches proposed, this approach may be a relatively simple way to get obtain [sic] a 'ball park' or order-of-magnitude estimate of benefits. (EPA Science Advisory Board 2002, 3)

This chapter thus addresses the theoretical issues identified by the EPA Science Advisory Board and others, evaluates and applies the current peer-reviewed economics literature, and develops an order of magnitude estimate of the benefits of NPL site remedial actions. The next section provides an introduction to the use a benefit-transfer analysis for estimation of Superfund benefits. The third section of the chapter discusses theoretical concerns associated with the analysis. The fourth section presents the methods and data used in both the meta-analysis and benefits transfer. The fifth section presents and discusses the results.

Use of hedonic analysis for estimation of Superfund benefits

The economic benefits of public investments can be approached by focusing on measures of individual satisfaction or well-being, referred to as measures of welfare or utility. Economic theory assumes that individuals can maintain the same level of utility while trading-off different "bundles" of goods, services, and money. The willingness to trade off compensation for goods or services can be measured either as *willingness to pay* (WTP) or as *willingness to accept compensation* (WTA). Economists generally express WTP and WTA in monetary terms. In the case of an environmental policy, willingness to pay is the maximum amount of money an individual would voluntarily exchange to obtain an improvement in the relevant environmental effects. Conversely, willingness to accept compensation is the least amount of money an individual would accept to forego the improvement.

A challenge in analyzing the benefits of the Superfund program is that there are no markets for any of the approaches that the Superfund Program takes. Economists have developed other methods for eliciting values for these types of effects. These methods rely either on information from the markets for related goods (revealed preference methods) or on direct information on people's preferences (stated preference methods). The hedonic property model (HPM) is a revealed preference methodology that has been applied to sites with hazardous substances on them (U.S. Environmental Protection Agency 2000, 71, 75, 77-79).

Hedonic price theory assumes that consumers value heterogeneous goods (such as houses) based on characteristics that are both intrinsic to the items themselves and external to the item.[1] In this sense, individuals view housing units as bundles of attributes and derive different levels of utility from different combinations of these attributes. Relevant characteristics may include structural attributes (e.g., number of bedrooms and age of house), neighborhood attributes (e.g., population demographics, crime, and school quality), and environmental attributes (e.g., air quality and proximity to hazardous waste sites). According to hedonic price theory, when decisions to buy and sell are made, individuals make tradeoffs between money and these attributes. Observing the buying and selling behaviors of individuals reveals the marginal values of these attributes and is central to hedonic property value studies.

Thus, differences in the prices for heterogeneous goods can be used to estimate the implicit value that markets place on the characteristics of those goods. Relevant characteristics include proximity to NPL sites. Because actual behaviors (i.e., home purchases) are used for data, such revealed preference methods are less vulnerable to strategic manipulation and study design problems than stated preference methods, which rely on surveys and questionnaires. Hedonic property value studies use statistical regression methods and data from real estate markets to examine the increments in property values associated with different attributes. One of the attributes that has been investigated in the literature is proximity to NPL sites.

Although data on home sales near NPL sites is available, it would be prohibitively expensive to purchase for any large number of sites. One approach to solving the problem of sparse data is to conduct a benefits transfer analysis, in which the results of previous research are applied to a new context (Rosenberger and Loomis 2003). Rather than collecting primary data, the benefits transfer approach relies on information from existing studies that have used a primary approach, such as a hedonic property study. In the current study, this approach is taken.

Four major caveats apply to this analysis. First, the current analysis includes perceived risks and uncertainty. Second, it ignores many benefits, including any benefits to non-neighbors or benefits that consumers do not include in home purchasing decisions. Third, the hedonic studies upon which the current study is based are themselves only partial estimates of benefits because non-use values are excluded (Boyle 2003). Finally, the current study ignores all Superfund activities other than NPL site remedial actions. For instance, the removals program is ignored in the analysis of this chapter, even though it may be responsible for a non-trivial part of short-term risk mitigation associated with Superfund and is much larger (by number of actions) than the NPL (Hird 1994, 31-32, 112; Probst and Konisky 2001, chapter 2).

The next section of the chapter discusses theoretical concerns associated with the benefits transfer analysis. The third section presents the methods and data used in both the meta-analysis and benefits transfer. The fourth section presents and discusses the results.

---

[1] Heterogeneous goods, such as automobiles and houses, are sold within a single market but can vary in characteristics. They can be contrasted to commodity goods, such as minerals and basic foodstuffs, which are sold in a single market but do not vary much.

Theoretical concerns with hedonic valuation

Overview

The theory of hedonic valuation begins with the observation that some products can be differentiated by the quantities of various features they possess (Rosen 1974; Freeman 1993). For residential real estate, these features include size, number and type of rooms, age, neighborhood characteristics and environmental amenities. The consumers of different types of the product (e.g., new, detached single family homes or condominiums in a refurbished factory) derive utility from the characteristics of the product, while producers or sellers incur costs that are dependent on the type of product they provide (Palmquist 1992a; McConnell 1993). Market prices are set by the interaction of the supply and demand schedules.

Rosen (1974) first modeled the interactions of consumers and producers in such a market. He developed the hedonic price function (sometimes called the hedonic model), P = P(**z**), where vector $\mathbf{z} = (z_1, z_2, \ldots z_n)$ represents the characteristics of the product. Rosen also developed a hedonic production function in which each producer chooses the variety of products he will produce and the number of each type. He then examined the equilibrium properties of such a market. His analysis improved the practice and interpretation of analyses in which the observed prices of the differentiated product are regressed on relevant attributes (including environmental amenities) in order to obtain estimates of the contribution of each attribute to the total price (Boyle and Kiel 2001).

An example of a relevant hedonic model is shown in Equation 4.1 (Kiel and Zabel 2001). In this specification, the price for house *i* at time *t* (P_{it}) is a log-linear function of home characteristics (H_{it}), neighborhood characteristics (N_{it}), and characteristics of the closest NPL site (S). The home and neighborhood characteristics examined by Kiel and Zabel include finished area (sq. ft.), age (date constructed), style (ranch, split, Cape Cod, colonial), unemployment at the census tract level, and median household income at the census tract level. The function that models the effect of an NPL site, $S(D_i;\theta_t)$, is more sophisticated than most other models in the literature, accounting both for distance (D_i) and for phases in the remedial process (θ_t). Otherwise this sort of specification is quite typical in the literature, with minor differences such as functional form or the inclusion of different home and neighborhood characteristics (e.g., number of bedrooms, racial makeup).

$$\ln P_{it} = \beta_{0t} + H_{it}\beta_{1t} + N_{it}\beta_{2t} + S(D_i;\theta_t) + u_{it} \quad \text{(Equation 4.1)}$$

In a hedonic analysis, the data are the price and characteristics of each home, and the results are the estimates for the parameter values, especially *S*. In a benefits transfer analysis, these results are the data. That is, this study will use estimates of the effect of proximity to NPL sites found in prior research and apply them to a larger set of NPL sites.

Several sources provide guidance on how to conduct a benefits transfer analysis with hedonic data. Bartik and Palmquist discuss theoretical issues of hedonic valuation theory as applied to amenity improvements (Bartik 1988; Palmquist 1991; Palmquist 1992a; Palmquist 1992b). Several recent references summarize good practices in benefits transfer (U.S. Environmental Protection Agency 2000, 85-87; Rosenberger and Loomis 2003). In a review of a study much like the one mentioned above, the EPA's Science Advisory Board (SAB) raised six theoretical concerns, each of which is discussed below (EPA Science Advisory Board 2002).

Market Size

The first theoretical concern involves the fraction of the housing market that homes near NPL sites make up. Palmquist, who focused on hedonic production functions and market equilibria, first raised questions about the size of the market relative to the environmental (dis)amenity thought to affect prices (Palmquist 1991). At the time Palmquist was writing, air pollution studies dominated the literature on hedonic price studies of environment and home prices. As a relatively large-scale phenomenon (city-wide or larger), air pollution is challenging for hedonic studies since, as Palmquist noted, "the prevalent view ... is that the housing market within a city is a single entity, whereas the housing markets in cities that are separated by significant distances are separate entities" (Palmquist 1991, 89). This "market size condition" suggests that hedonic price studies attempting to evaluate environmental disamenities should evaluate markets in which consumers have options that include housing not affected by the environmental disamenity. Although NPL sites have much more localized effects than air pollution, this problem can still arise because some areas have many NPL sites, thus affecting a large fraction of the housing market. For instance, the SAB expressed concern about the proposed study of underground storage tanks because data from New York State indicated that 23% of residences are located near the sites proposed for analysis (EPA Science Advisory Board 2002, 21).[2] Although concern was raised, no specific acceptable threshold was established.

To examine the importance of the market share problem for this analysis, the fraction of residences near NPL sites was calculated for several relevant counties and metropolitan statistical areas (MSAs), as well as for the nation as a whole. Actual site boundaries for NPL sites are not generally available in a database, but latitude and longitude and site area are typically given for each NPL site. Using GIS software, a circular area for each NPL site was created, centered on the given point and with an area equal to that of the site. Areas within 1, 2.5, and 4 miles of the sites' circular pseudo boundaries were delineated. Using U.S. Census data at the block level, the number of residences within these areas was counted, assuming uniform density across each block. (See Chapter 3 for the relevant details.) Spot checks at NPL sites for which boundaries were known indicated this approach introduced only small (<2%) errors in estimates of the number of residences near NPL sites up to the 2.5-mile distance. Following the practice in the literature, residences are counted only once, even if they are near two or more NPL sites.

By comparing the number of residences within these areas with the total number of homes available to consumers, it is possible to assess how well the market size condition is met. The results vary greatly with the geographic extent used to define the market. However, it is important to define the market carefully because different specifications of what makes up a housing market can strongly influence whether or not the market size condition is met. This definition must include both “where” the market is, and “when” it is.

---

[2] Note that the market size condition is only a test that indicates if the HPM is appropriate or not; market size does not enter into hedonic models directly.

For instance, consider the housing market relevant to the two NPL sites in Woburn, Massachusetts, a suburban town located in Middlesex County and in the Boston MSA, as illustrated in Figure 4.1. This figure shows the location of places near NPL sites (site area plus a 2.5-mile ring), state and census tract boundaries, and the area of the Boston MSA.[3] First, consider the "where" question. Potential buyers in 2004 looking for homes in Middlesex County would find a market in which 40% of all residences are within 2.5 miles of any NPL site that has ever existed. But if they were willing to consider homes anywhere in the Boston MSA, then only 25% of homes are near NPL sites. And, if they were willing to look for homes in Worcester County, which borders Middlesex County to the west, is partly within the Boston MSA, and is about 20 miles from Woburn, they would face a housing market in which only 5% of all homes are near NPL sites.

Thus, how well the market size condition is met depends in part on how large an area potential homebuyers and renters search for homes, which relates to commute lengths. Housing data suggest that the mean commute trip length for first-time homeowners and recent movers who live in MSAs is 15.6 miles nationwide, while even higher values are observed in densely crowded places like Boston (Anonymous 2000, Exhibit 48). These data suggest that households may be willing to move ten miles or more and still have acceptable commute lengths, especially if the move is not directly away from the workplace. Thus, a move from near the Woburn NPL sites in 1984 to Worcester County seems at least plausible. This conclusion is in agreement with Palmquist: "for real estate markets, a majority of researchers seem to favor urban area markets" (Palmquist 1991, 120). That is, housing markets are not national, but neither are they generally limited to a single city, county, or even MSA. This analysis suggests that even for the Boston area, which has a major concentration of NPL sites, the market size condition is met.

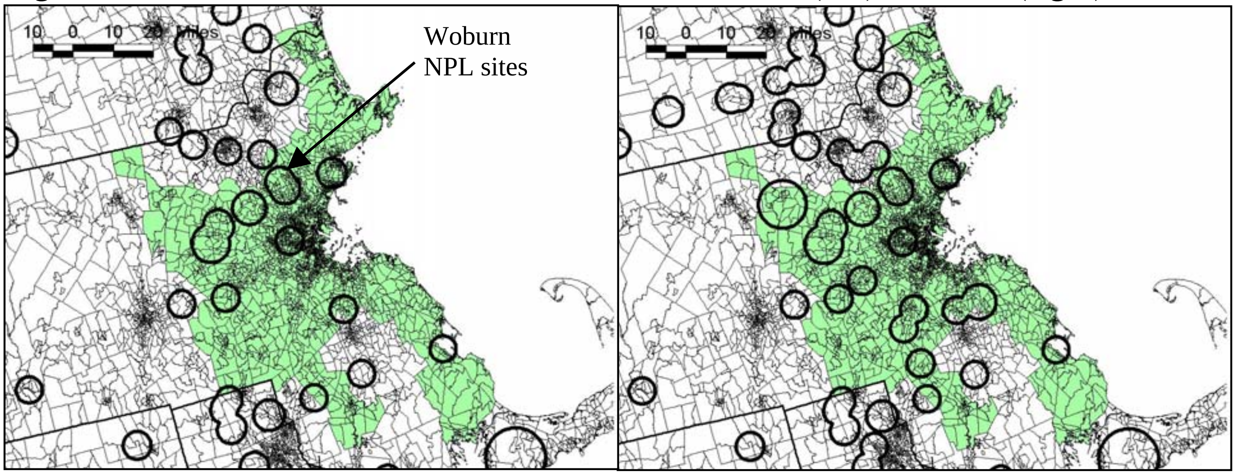
Now consider the "when" question, which is also illustrated in Figure 4.1. This figure shows areas near all NPL sites (proposed listed, and deleted) in 1983 and 2004, on the left and right, respectively. Because the NPL was created in 1983 and no sites had yet been deleted from it, all of the areas in the left map are near either proposed or listed NPL sites. These would have affected housing markets in 1983. However, sites that were proposed for, or added to, the NPL subsequently (those additional sites on the right-hand side of Figure 4.1) would not have been known in 1983 and thus could not have affected the housing market at that time. Accounting for this difference significantly affects the market size calculation above. For instance, if the 1983 data are used then only 18% of homes in the Boston MSA (not 25%) are near NPL sites.

There is a further aspect to the "when" question: NPL sites that receive remedial actions and are cleaned up should not cause a disamenity. All the calculations of market size above are based on the cumulative number of sites that have ever been on the NPL for a given area. A more accurate estimate would be based on the number of NPL sites perceived as disamenities at any given time, which, for reasons discussed below, is defined as those that were discovered but for which no remedy had yet been determined. This is the number of sites on a national basis that have been discovered but for which no ROD has yet been issued. Using this definition, the number of sites that would be considered disamenities by potential home buyers was approximately equal to the number of NPL sites for 1983-1984, but as plans for cleanup began to

[3] Because census tracts all contain approximately the same number of people, their size (or the density of their boundary lines) is an indication of population density.

be determined, tended to become smaller after that.[4] The number of such sites peaked in1990 at about 638, or about half the number of NPL sites at the time. Since then, the number of NPL sites presenting disamenties to housing markets has declined to under 300, or less than 20% of all sites that have ever been placed on the NPL.

Figure 4.1. Areas Near NPL Sites in the Boston Area, 1982 (left) and 2004 (right).



NOTE: Boston MSA is shaded. Includes all sites proposed to, on, or deleted from the NPL. State and census tract boundaries are shown.

The image on the right side of Figure 4.1 shows all sites that have ever been placed on the NPL in the Boston area, so it, shows a greater fraction of the land area as near NPL sites than would have been perceived as such by the housing market in either 1982 or 2004. Similarly, the percentages calculated above all overestimate the fraction of the housing market with NPL-related disamenities because they are based on the cumulative number of sites that have ever been proposed for or placed on the NPL. Nonetheless, these images show the general pattern of population and NPL sites in the area. Analysis of other parts of the country shows a similar pattern.

These values seem less important than the observation that in all cases, there appear to be significant numbers of homes not near NPL sites that would keep commute lengths close to the mean distances observed in urban areas in the United States. Therefore, while the number of homes that are near historical NPL sites may be high enough to raise concerns about the market size condition, the current analysis suggest that these concerns are not significant for this study because of spatial and temporal variations, along with the willingness of Americans to accept long commutes. As shown in the Woburn example above, the market size condition appears to be met, although by what margin it is met is dependent on how the homebuyers' housing markets are defined.

Ex Ante Data

The SAB's second theoretical concern was articulated by Bartik (1988), who argued that, "the property value increases due to amenity improvements predicted by the original hedonic property value function will generally overestimate benefits," because the adjustments by buyers and

[4] See Figure 3.3 for a graphic representation of the trend of these “No ROD” sites.

sellers are not taken into account (p. 173). However, this market adjustment problem applies only to the application of ex ante hedonic studies to consider ex post conditions, which is not the case here. The hedonic studies upon which the benefits transfer analysis in this study are based all utilize observations of ex post data, not estimates based on ex ante hedonic price functions. In some cases both ex post and ex ante data are used, but in no cases are only ex ante data used.

Relationship

The SAB's third theoretical concern is about the strength and character of the relationship between the amenity improvement and the change in real estate prices. That is how well established is the causal linkage between the amenity improvement and the change in home prices? One possible weakness with this causal linkage relates to the possibility that perceived and actual risks may differ. Expert and popular views of the likelihood and magnitude of risks are often different, and in the case of hazardous waste the popular opinion rates risks higher (Slovic, Fischhoff et al. 1979; U.S. Environmental Protection Agency 1987). However, it is not clear that only the risks of negative health outcomes (actual risk) motivate changes in real estate prices. Perceived risk and uncertainty have been found to have a significant influence on home prices (McClelland, Schulze et al. 1990; McCluskey and Rausser 2001; Gayer and Viscusi 2002). However, the problem of differences in perceived and actual health risks may not matter for this study because the HPM studies used here are not designed to distinguish between perceived and actual risk, and no claim is made here that they do. This issue is analyzed in more depth later in this chapter, in the section on observations of the reversal of the negative price effect.

A related but somewhat different effect is called stigma - the rejection of people, places, or objects as fundamentally discredited, flawed, or spoiled (Gregory, Flynn et al. 1995; Kasperson, Jhaveri et al. 2001). Potential hazards possessing psychologically powerful characteristics that tend to raise perceived risk above actual risk are good candidates for stigmatization. These characteristics include dread consequences (e.g., cancer), violations of rights or standards, inequitable distribution of impacts (e.g., if most of the risk is to children), and involuntary exposure. All of these characteristics might apply to an NPL site. But not all risks become stigmatized. A critical feature of stigmatization is that "a standard of what is right and natural has been violated or overturned because of the abnormal nature of the precipitating event...or the discrediting nature of the consequences" (Gregory, Flynn et al. 1995). When this happens, there has typically been an initiating event that signals a new or different risk. Then, "extensive media coverage interprets the meaning and projects risk signals, imputing blame, trustworthiness, vulnerability, and victimization" (Kasperson, Jhaveri et al. 2001, 16). This leads to a social amplification of the risk and tightly identifies the person, place, or object with the negative, threatening characteristics of the hazard, even if the actual risk declines. There is some evidence, discussed below, that this has occurred at some NPL sites but not others.

In addition, uncertainty may play a significant role. The data needed to adequately assess the actual risk associated with NPL sites is typically not available even after lengthy study, and is certainly not available when a site is first placed on the NPL (Viscusi, Hamilton et al. 1997; Johnson 1999; Harrison 2003). Homebuyers are thus faced with a choice that may entail significant risk that they cannot assess very well. In the face of such uncertainty, homebuyers may well be risk averse. Gayer et al. examined this effect in detail and found a significant change in the disamenity associated with NPL sites as more information became available about them (Gayer, Hamilton et al. 2002). In this sense, the Superfund program reduces uncertainty, which should improve the efficiency of housing markets.

Therefore part of the causal linkage is as follows. The discovery of an uncontrolled release of hazardous substances creates concern about human health risks. Due to a lack of data about the site, this concern includes considerable uncertainty. The process of investigating the site, developing a plan for remedial action, and documenting it in a ROD significantly reduces these uncertainties. There is evidence that the release of the ROD seems to have a positive effect on home prices (see the discussion below in the Meta-analysis: Reversal section).

An additional part of this third theoretical concern is the problem that there may be health, ecological or other benefits that accrue to people other than those who buy houses close to NPL sites or that are not part of home buying decisions, which hedonic analysis systematically excludes. This is clearly an important effect. Reviews of RODs indicate that benefits do occur that are unrelated to home purchasing decisions and relevant to many people who do not participate in housing markets near NPL sites (Walker, Sadowitz et al. 1995; EPA Science Advisory Board 2002). For instance the value of leaving clean ground water for future generations to use motivates many decisions at NPL sites. While these people might value the availability of uncontaminated drinking water, most of them will not be neighbors of former NPL sites and thus their WTP would not be included in data from housing markets near NPL sites. Furthermore, the WTP for future neighbors of former NPL sites would be discounted in private decisions about home prices. While this is appropriate for individual decision-making, it is not appropriate when considering the societal value of those preferences (U.S. Environmental Protection Agency 2000, 71, 75, 77-79). Thus, it would be incorrect to assume that a valuation estimate based on changes in home prices alone would be complete.

The timing of changes in property values near NPL sites is also an important part of this concern. At issue is whether housing markets adjust quickly or slowly to new information. It is clear that at least some of the effect of a disamenity can be capitalized into housing markets fairly rapidly. For instance, Kiel and McClain looked at how house prices responded to an ultimately unsuccessful attempt to site a new incinerator in Woburn, Massachusetts (Kiel and McClain 1996). Housing prices declined when the incinerator was proposed and then fully recovered when plans were canceled. However, other studies have found that the adjustment period until the market returns to equilibrium can be quite long (McMillen and Thorsnes 2000; McCluskey and Rausser 2001; McCluskey and Rausser 2003a). Similarly, Kiel and Zabel noted that research on the capitalization of public goods shows that their values are often not fully capitalized in home prices (Kiel and Zabel 2001, 181). Thus, they suggested that hedonic property valuations are likely to be underestimates of the health benefits of remedial actions at NPL sites.

Another factor that may influence the magnitude and timing of changes in housing prices near NPL sites, and therefore the causal linkage between amenity improvement and price changes, is demographic change (Cameron and Crawford 2003; McCluskey and Rausser 2003a). This phenomenon starts with the discovery of an environmental risk, which reduces the value of housing stock near the site, inducing high-income families to move out and permitting low-income families to move in. If a sufficiently large change occurs, then the neighborhood itself changes in ways unrelated to the health risk posed by the NPL site but associated with lower average income: declines may occur in school quality, police attention, social status, and owner-occupancy rates. Moreover, because race and income are related, racial makeup may change. These changes will remain even if the original factor, increased health risk posed by the NPL site, is mitigated, creating a long-term effect. McCluskey and Rausser present anecdotal arguments and some econometric analysis to support this idea, while Cameron and Crawford, using a larger data set covering more sites find no consistent pattern (Cameron and Crawford 2003; McCluskey and Rausser 2003a; McCluskey and Rausser 2003b). Because the literature on neighborhood change is inconclusive, this effect is ignored.

Comparability
The SAB's fourth theoretical concern is the need for comparability between the study sites and the policy sites, the appropriate distance to select, and the use of non-peer-reviewed data. The HPM studies used in this analysis include data on a total of 40 hazardous waste sites, of which 24 are NPL sites. Of these sites, six NPL sites and all sixteen non-NPL sites are located in the Northeast; of the remaining NPL sites eight are in the Midwest, one is in Texas, and two are on the West Coast. This very roughly approximates the regional distribution of NPL sites in the country, with the exception that there are no study sites in the rural West or the Southeast. The sites include waste dumps, former manufacturing facilities, and smelters, common types of NPL sites. All are located in MSAs and because 80% of all NPL sites are in MSAs and over 95% of homes near NPL sites are in MSAs, this seems representative as well. (See also Chapter 3)

Pooled Data
The SAB's fifth theoretical concern is how the housing data are pooled. Michaels and Smith segmented the housing market into various categories ("Average," "Premium," etc.) and showed that the estimated effects of a hazardous waste site depended on whether the estimate was performed on an average basis or on a segmented basis (Michaels and Smith 1990). For more expensive categories, the price effect tended to be a larger fraction of home price (and thus much larger in absolute magnitude). More recent studies have found the same effect (Nelson, Genereux et al. 1997; McCluskey and Rausser 2003). These studies show that differences in how real estate markets are pooled in hedonic studies can create differences in estimated effects, and single pools are likely to be underestimates. The studies used here for data (see Table 4.2) generally pool the markets they examine into a single category, suggesting the resulting estimates of the price effect are underestimated.

Equilibrium Conditions
The last of the SAB's theoretical concerns is that hedonic valuation assumes equilibrium in a perfectly competitive market with no transaction costs and perfect information (Freeman 1993; McConnell 1993). These conditions rarely apply to housing markets since search and moving costs are so high, possibly several percentage points of home price. The problem of transaction costs has received little or no treatment in the literature. Because transaction costs tend to create a wedge between equilibrium housing prices and consumers’ WTP for avoiding NPL sites, they can cause estimates using observed prices to be underestimates of the actual change in value.

McConnell noted that one of the principal problems associated with assessing the impacts of NPL sites is that hazardous substances may injure in ways that are not directly perceptible by individuals (McConnell 1993). Therefore, people must rely on secondary sources of information. The dominant source of information for most people is the news media, which can amplify the perceived level of risk (Kasperson, Jhaveri et al. 2001; Gregory and Satterfield 2002). On the other hand, Lipscomb et al. have shown that knowledge about health risk assessments can fade, and Hite found evidence that homebuyers may be poorly informed about locally undesirable land uses (LULUs) such as landfills (Lipscomb, Goldman et al. 1992; Hite 1998). Thus, while imperfect information and uncertainties about risks due to proximity to NPL sites may be common features in real estate markets, it is not clear in which direction this effect will tend to bias the result.

The potential biases in this analysis are summarized in Table 4.1, which suggests that overall, the methods used here may be subject to biases both up and down, with more biases that would produce an underestimate. The review above also supports the idea that a HPM-based benefits transfer analysis is likely to produce an estimate applicable only for the NPL program as a whole, and the results are not transferable to any specific site. That is, the analysis contained in the remainder of this chapter applies only to the NPL in aggregate, not individual NPL sites.

Table 4.1. Potential Biases in the Hedonics-Based Analysis

Type of bias	Perfect competition and no transaction costs	Perfect information	Pooled data	Not in market
Direction of estimate	Underestimate	Not clear	Underestimate	Underestimate

Method

Overview

A benefits transfer analysis is used to apply information from previous HPM studies to places near NPL sites that are expected to have experienced a reversal of a negative price effect. A complete reversal of the negative price effect is assumed. The value being transferred is the effect of proximity to an NPL site on home prices. Using estimates of central tendency, two estimates are calibrated for distance and thus use non-linear price effect estimates developed below. The procedures outlined in Rosenberger and Loomis (2003, Tables 3 and 7) are used. For the purposes of this analysis, three specific questions addressed by the literature applying HPM to NPL and other hazardous waste sites are most important. How large an effect do NPL and other hazardous waste sites have on residential home prices? What events cause a decline in prices to occur? And what, if any, events reverse the negative price effect? This section first examines several aspects of the meta-analysis, the magnitude of the effect, the cause of the effect, and cause of reversals of the effect. Then the benefits transfer analysis is discussed.

Meta-analysis: Magnitude

The policy context is the NPL from its creation in 1982 through 2004, limited to sites within the 50 states because sufficient data on sites in U.S. territories were not available. Data for 1,572 sites on the NPL through the end of fiscal year (FY) 2003 are available in CERCLIS. Benefits are transferred only to those sites that are expected to have their values restored, which, as discussed below, are those sites for which a record of decision (ROD) has been issued.[5] This amounts to 1,326 sites by the end of FY2004, using EPA estimates of the number of sites for which a ROD will be issued in FY2004. Thus, this analysis is retrospective only and requires no assumptions about future NPL sites.

A literature search was conducted using EconLit, Web of Science, several electronic catalogs from the University of California library, and email and personal queries to experts to seek out gray literature.[6] This yielded over 30 reports, book chapters and peer-reviewed papers on hedonic analysis relating to Superfund or hazardous substances. These studies were evaluated for relevance (including reporting data usable in this study), originality (i.e., no review articles), and quality (e.g., only studies published in peer-reviewed, archival journals). This literature search resulted in nine studies that presented original data suitable for use in this benefits transfer analysis.[7] Using language from the EPA's *Guidelines for Preparing Economic Analyses*, these nine HPM papers are the policy studies for this chapter and the sites they evaluate make up the "Property" group defined in Chapter 3.

Key characteristics of these studies are shown in Table 4.2. The 2.5-mile areas associated with these sites are shown in Figure 4.2. They are distributed around the country, although somewhat concentrated in the Northeast and Midwest. All price information is given in 2000 dollars, adjusted by the Bureau of Labor Statistics' Consumer Price Index for all goods for all urban consumers per Boyle and Kiel (2001).

A number of studies did not provide price effect data usable for this study or reported on the same data set, but were otherwise informative in terms of the distance from the site that they found an effect, or other insights (Smith and Desvousges 1986; Kohlhase 1991; Gayer, Hamilton et al. 2000; McMillen and Thorsnes 2000; Gayer and Viscusi 2002; McCluskey and Rausser 2003; McCluskey and Rausser 2003; McMillen 2003).

Some of the studies in Table 4.2 (those labeled 'C') use only cross-sectional data. They examine home sales over a relatively short, fixed period (usually several years) and compare homes that are near NPL sites with those that are more distant. That is, they do not look at prices before or after any specific event. Most of the studies in Table 4.2 (labeled 'P') use panel data sets that include both longitudinal and cross-sectional information. These examine home sales over a longer period, grouping sales by changes in site status or available information. Longitudinal studies may rely on repeat sales of the same home, which avoids the problem of potentially omitted variables. In some longitudinal hedonic studies, data may be collected for the period

---

[5] Although some sites have multiple RODs, for the sake of simplicity this study used the first ROD issued for each site.

[6] Gray literature is a term used to describe unpublished studies, dissertations, and papers that if not uncovered may introduce bias into a meta-analysis since published studies are typically ones that find positive results.

[7] There is some disagreement between the EPA *Guidelines for Preparing Economic Analyses* and some of the most recent literature on meta-analysis (Stanley 2001) regarding the issue of inclusivity (all studies) versus selectivity (peer-reviewed studies only). There is controversy within the literature as well (see the subsequent commentary on Stanley in 61(3) of the same journal). One suggested problem is double counting datasets used in multiple studies, which is more likely to be a problem in non-peer-reviewed studies. McClelland and Schulze et al. (1990) and Hurd (2002) share some data, but really represent different data sets, and so avoid this potential problem.

before the site is proposed for listing on the NPL, while the facility is operating, after it is listed, and then after the remedial action.

Table 4.2. Hedonic Price Method Studies of Homes Near Hazardous Waste Sites

Study	Absolute effect (2000$)	Percent effect	Number of sites	Number of observa-tions	Cross-sectional or Panel	Period	Maximum Distance
(McClelland, Schulze et al. 1990)	$16,264	7.3%	1	178	C	83-85	-
(Michaels and Smith 1990)	$352	-	11	2,182	C	77-81	6.2 mi
(Mendelsohn, Hellerstein et al. 1992)	$11,804	7.5%	1	1,916	P	69-88	2 mi.
(Thayer, Albers et al. 1991)	-	-	16 non-NPL	2,323	C	85-86	4 mi
(Reichert 1997)	$9,156	7.1%	1	1,586	P	77-94	2.5 mi
(Dale, Murdoch et al. 1999)	$24,745	16%	1	203,353	P	79-95	2 mi
(Kiel and Zabel 2001)	-	-	2	2,209	P	75-92	2.5 mi
(Gayer, Hamilton et al. 2002)	$3,134	3.4%	7	1,883	P	88-93	4 mi
(Hurd 2002)	$6,664	3.1%	1	not given	P	83-85 94-97	3,000 ft

Note: Absolute values are per home. Percentages based on study-specific mean prices, where available.

The nine studies in Table 4.2 all report results from different data sets, although the data used by Hurd (2000) includes that used by McClelland, Schulze et al. (1990). All the policy studies evaluate NPL sites except Thayer et al., which evaluates other sites with hazardous waste on them (Thayer, Albers et al. 1991). Most of the policy studies use about two thousand observations; McClelland, Schulze et al. (1990) use an unusually small set and Dale, Murdoch et al. (1999) employ a very large data set. The maximum distance at which an effect is detected ranges from 0.57 miles to 6.2 miles, with a mean of 3.0 miles. Five studies find an effect at or beyond 2.5 miles and only two do not.

Table 4.3 presents information on the dates of key events at the study sites and when the data used in each study were gathered. No data is shown for Thayer et al. (1991) because it is not available. Table 4.3 also contains information on the study by Kohlhase (1991) because of its relevance to the question of the timing of the price effect. Numbers are given on the left to identify the studies, next to the names of the NPL sites. The table is filled in with letters representing different events. The keys for the numbers and letters appear at the bottom of the table. The grid squares in the table are colored to show the years for which the data were gathered for each study. If the study is cross-sectional, different periods are shown with different shades. For simplicity only two shades are used, even if more than two periods were defined in the study, which was the case for peer-reviewed papers (Dale, Murdoch et al. 1999; and Kiel and Zabel 2001).

Figure 4.2. Places Near NPL Sites in the Coterminous United States (Site Area Plus 2.5 Mile Circles) and Location of Study Sites

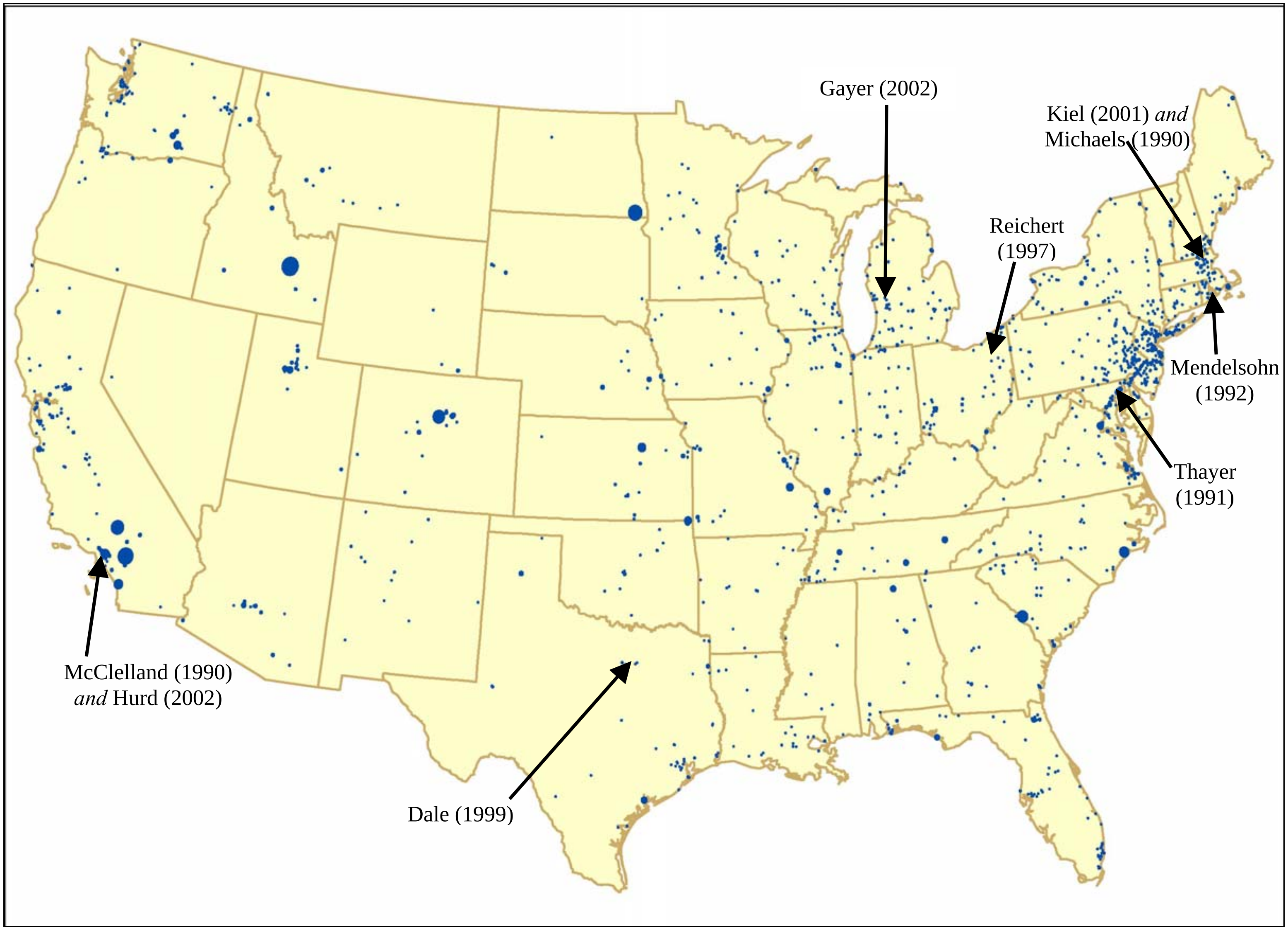


Table 4.3. Events and Data Collection for HPM Study Sites

Study	Site Name	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04
1, 9	Operating Indust.					D					P		L	ERS															E		
2	Industri-Plex					D			P	L			ER		E				S												
2	Nyanza Chem.						D		P	L		R		SE	E	E			E												
2	Salem Acres						D				P		L		E		E			R	S					C		X			
2	W.R. Grace					D			P	L						R				S											
2	Wells G&H					D			P	L			E	E	E	R			S												
3	Brio Refining								D		P	E			R	LS															C
3	Crystal Chem.						D		P	LE					E		R	E				S								C	
3	Geneva Indust.							D		PE	LE		R	S						C											
3	Harris (Farley)								DP	L		R	S		CX																
3	N. Cavalcade St.										DP		L		R			S													
3	Sol Lynn										DP				R	LE		S		C									E		
3	S. Cavalcade St.									D	P		L		R							S					C				
4	New Bedford	(Data from 1969)				D			P E	L	E	E					R	S													
5	Indust. Excess						D				P		L	R	E	S				E											
6	RSR Smelter							D												P		LER					S		E		
7	Industriplex					D			P	L			ER		E				S												
7	Wells G&H					D			P	L			E	E	E	R			S												
8	Butterworth #2					D			P	L						E	E		R						S		C				
8	Chem Central				D				P	L								R			S	C									
8	Folkertsma Refuse							D					P			L		R		S	C		X								
8	H. Brown Co.						D					P	L						ER							S	C				
8	Kentwood	(Data from 1971						P	L								R			S	C										
8	Organic Chemicals					D			P	L								R			S									C	
8	Spartan Chemical					D			P	L										R						S					

Legend:
Site: 1-McClelland 1990; 2-Michaels 1990; 3-Kohlhase 1991; 4-Mendelsohn 1992; 5-Reichert 1997; 6-Dale 1999; 7-Kiel 2001; 8-Gayer 2002; 9-Hurd 2002.
Events: D-Discovery; P-Proposed to NPL; L-Final on NPL; E-Removal Action; R-ROD; S-Start of Remedial Action; C-Construction complete; X-Deleted
Colors: Different shades indicate how panel data were divided longitudinally.

HPM studies of places near NPL sites evaluate only single-family, owner-occupied, detached (SOD) homes, and so provide no information on other types of residences or any benefits to the owners of commercial real estate near NPL sites. Palmquist suggested these differences are minor (1991,, 93-95), but this issue is investigated nonetheless. The Census data show that SOD homes are the largest residence type near NPL sites, representing 47% of all residences, and that single-family detached rentals accounted for another 8%. Other owner-occupied residences (duplexes, condominiums, etc.) account for 11%, and multi-family rental housing for 33%. Some studies include condominiums in their data, and the effect on prices for these properties are similar to those for other types (Hite, Chern et al. 2001; Ihlanfeldt and Taylor 2004). This suggests that for rental single-family detached homes and non-SOD owner-occupied dwellings, an SOD-based estimate may be reasonable, although possibly an overestimate since SOD home prices are typically higher than those for other residence types. Most studies ignore any differences and typically just scale the SOD-based estimate linearly with population (Gayer, Hamilton et al. 2000; Kiel and Zabel 2001). This convention assumes that the price effect is identical for all types of homes. The approach used here improves on a population-based approach by scaling the SOD-based estimate with the number of homes, and by conducting a sensitivity analysis for different kinds of residences.

Of the nine studies in Table 4.2, six provide only point estimates of the magnitude of the effect of proximity to NPL sites on home prices (called linear estimates because the value does not change with distance), two provide estimates that vary with distance from the site (called non-linear estimates), and two (Reichert 1997; Hurd 2002) provide both types of estimates. All point estimates reported here are *per home*, rather than *per home per mile*.

The linear estimates are shown in Table 4.4. The absolute estimates range from about $350 per home to almost $25,000. The mean value is $10,303 and the standard error is $3,129. The 95% confidence interval for the effect of proximity to NPL sites on SOD home prices is $7,173-$13,432. The percentage values range from 3.1% to 16%, with a mean of 7.4%. The standard error is 2.3 percentage points, so the 95% confidence interval for the effect of proximity to NPL sites on SOD home prices is 5.1%-9.7%. Figure 4.3 illustrates these data while Figure 4.4 illustrates the data for the non-linear estimates.

Table 4.4. Summary of Linear Price Effect Estimates Per Home (2000$)

	Absolute	Percentage
Minimum	$352	3.1%
Maximum	$24,745	16%
Mean	$10,303	7.4%
Std. Error	$3,129	2.3%

Figure 4.3. Linear Price Effect Estimates (2000$)

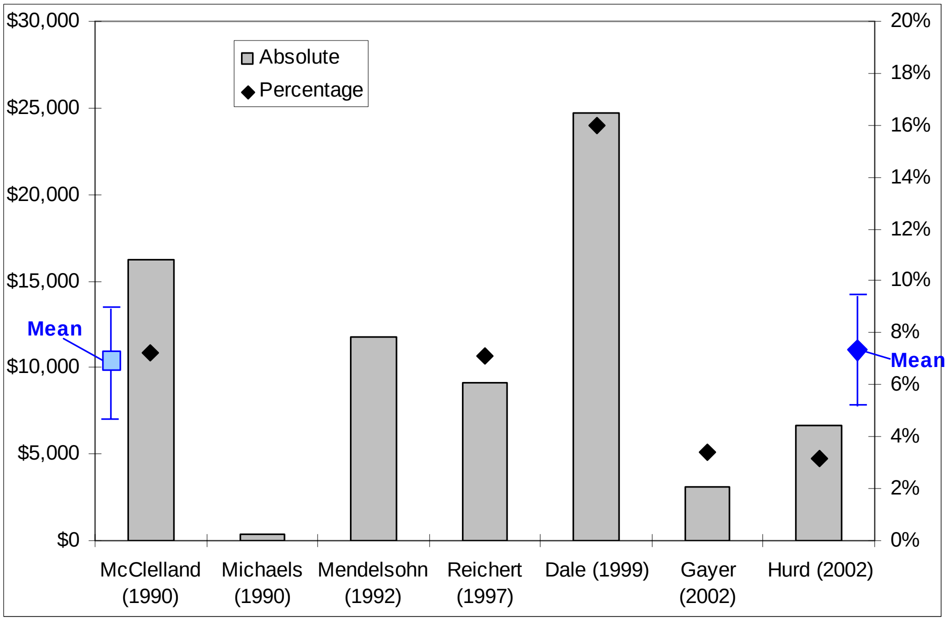
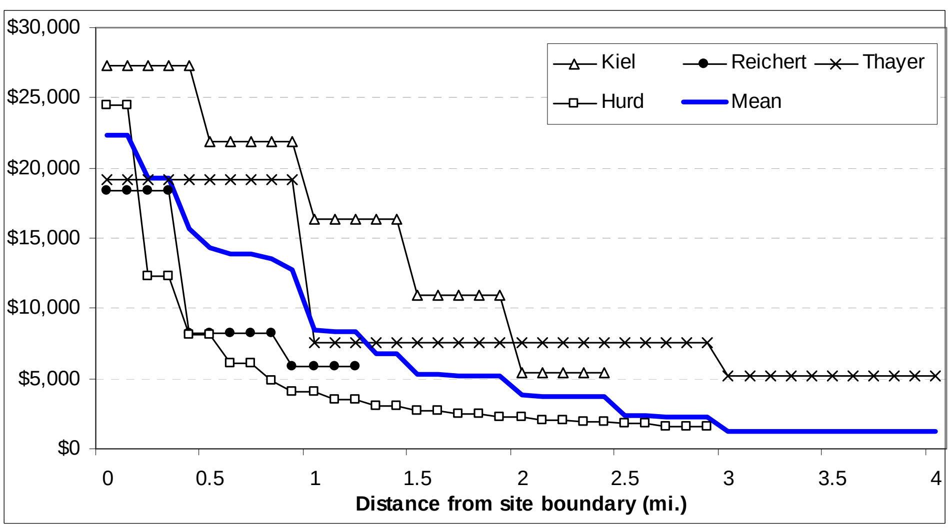


Figure 4.4. Non-linear Price Effect Estimates (2000$)



The mean estimates of the non-linear price effect (both absolute and percentage) are given in Table 4.5 as discrete values for various distances from the boundary of the NPL site; Figures 4.5 and 4.6 present this information graphically. For computational purposes, the mean values shown in Figure 4.5 are converted to mean values for each 0.5 mile increment. Of these studies only two, Kiel and Zabel (2001) and Reichert (1997) provided mean home price data that permitted us to calculate a non-linear percentage effect. Both the non-linear effect estimates at specified distances from the site, absolute and percentage, are shown in Table 4.5.

These curves can be considered measures of central tendency values for the benefits transfer analysis, with the non-linear estimate being calibrated for distance. In addition to curves for the four studies that report non-linear results, lines showing the mean values of the linear estimates (calculated at 0.1 mile increments) are given. These figures also show the 95% confidence intervals. The lower bound of 95% confidence interval for the non-linear percentage estimate changes from 3.8% to -1.6% from 1.2 to 1.3 miles (Figure 4.6). This is because the number of data points in the sample goes from four to three at that point. Because negative values are implausible, this implies that due to data limitations the estimate based on non-linear percentage effect (NLP) should be given less weight than the other effect estimates.

Table 4.5. Mean Estimates of Non-Linear Price Effect Estimates for Residences at Specified Distances (2000$)

Distance	Absolute	Percentage
r < 0.5	$41,194	14.5%
r = 1.0	$33,086	11.2%
r = 1.5	$26,613	8.7%
r = 2.0	$22,357	6.2%
r = 2.5	$19,411	3.1%

Figure 4.5. Mean Absolute Price Effect Estimates and 95% Confidence Intervals (2000$)

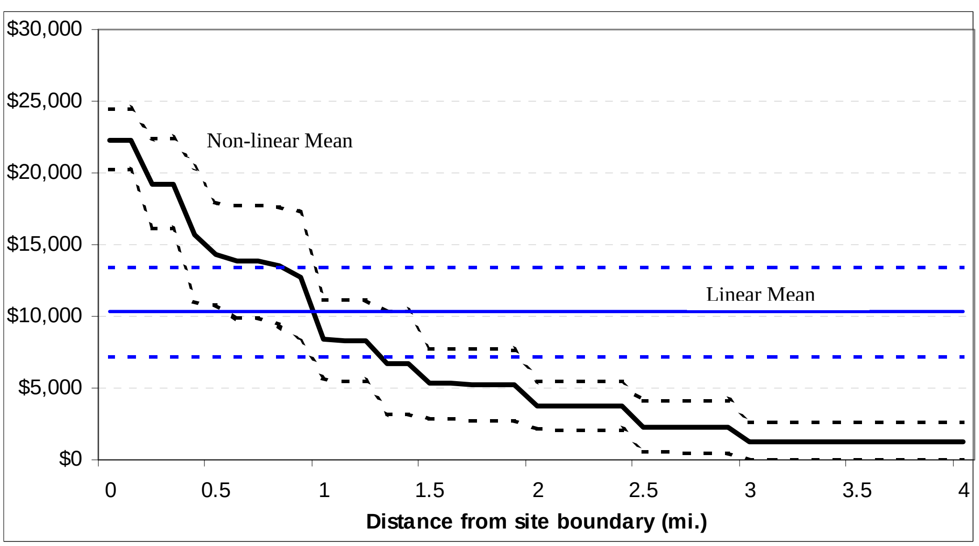
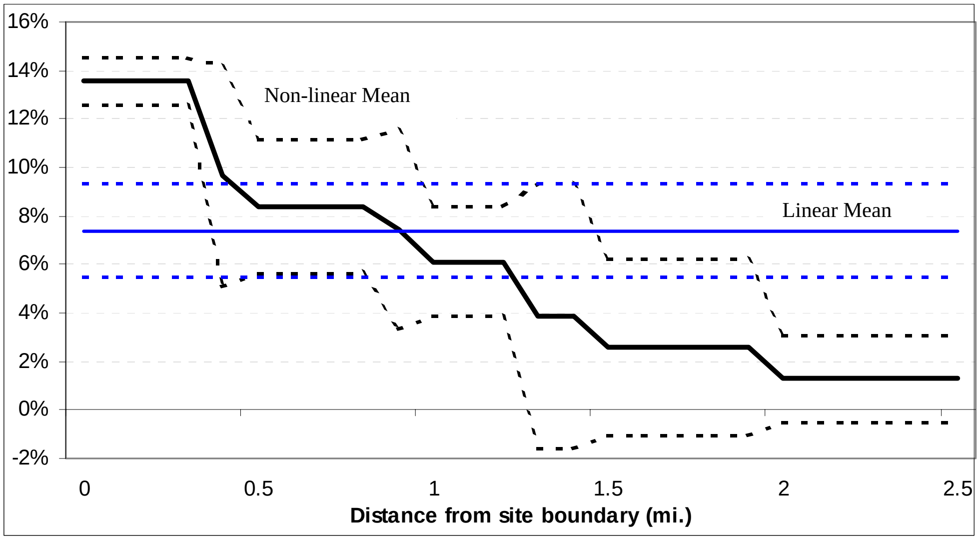


Figure 4.6. Mean Percentage Price Effect Estimates and 95% Confidence Intervals



Because changes in home prices are the basis for this analysis, it is important to determine how representative the home prices evaluated in the Table 4.2 studies are of the prices for all homes near NPL sites. Thus prices for homes in the HPM data set were compared with home prices in the rest of the United States. The U.S. Census reports that the median price for SOD homes in the U.S. in 2000 was $139,000 for existing units and $169,000 for new units (U.S. Bureau of the Census 2002, 592-3). Median SOD prices are also reported on the census block group level. The mean of these medians for census block groups within 2.5 miles of NPL sites, weighted by the number of homes in each block group, is $132,000. Seven of the studies in Table 4.2 reported the mean values of the SOD homes in their samples. The mean of these values is about $160,000. This is 22% higher than the national median value, but means tend to be higher than medians for data sets that have lower bounds (e.g., zero). Thus, it is reasonable that the home prices used in the studies in Table 4.2 are representative of home prices in the U.S. and homes near NPL sites. Table 4.2 summarizes the linear price effect estimates.

Having determined the magnitude of the decline in residential property values associated with proximity to NPL sites, the next issue is timing, for which the evidence is even more mixed. The general sequence of events that an NPL site will undergo includes: site discovery, proposal to the NPL (which most people take as being placed on the NPL), listing on the NPL, release of the Record of Decision (ROD) that documents the remedy selection, remedial action, construction completion (when the construction of the remedial action but not necessarily all treatment is essentially complete), and deletion from the NPL. (See chapter 3 for more information.) The dates for specific events in this sequence, along with the periods during which property data were collected for each study are shown in Table 4.3.

Meta-analysis: Decline
Sites that eventually end up on the NPL must be 'discovered' first. Discoveries of hazardous substance spills or hazardous waste are often made by concerned citizens, first responders (e.g., fire fighters or police), or local officials (Office of Technology Assessment 1989, 10-11; Hird 1994, 14-15, 19). Sometimes sites known to have hazardous substances may have no distinct discovery event and homes nearby may suffer a longstanding depression in home prices (Dale, Murdoch et al. 1999; McMillen 2003). In this section, we review the evidence on this point from each of the studies listed in Table 4.2 as well as comment on a small number of other relevant papers.

Kohlhase (1991) find no effects in 1976 and 1980, which is before discovery for all but one of the seven sites she examined (not in Table 4.2). She finds significant effects in 1985, which was after all seven had been discovered and proposed to the NPL, but after only three had been listed. Based on this evidence, Kohlhase suggests that the period 1980-81 is particularly important because this is the period during which CERCLA was passed and the NPL began. Before this period, she argues, housing markets may have not had site-specific information with which to assess hazardous waste sites.

McClelland et al. (1990) and Hurd et al. (2002), who examine the same site, find a negative price effect in 1983-85, several years after discovery but before the site is listed on the NPL (1986). The site was proposed for listing on the NPL in the middle of this period.

Michaels and Smith (1990) find a small effect using data from 1977-81, a period that covers both before and after discovery, but before any of these sites are proposed for the NPL (1982 or 1984). One reason for the very low values reported by Michaels and Smith (1990) is that most of their data comes from before discovery. Note that if Kohlhase's argument above is correct, it would suggest that the data collected by Michaels and Smith for 1977 and 1978 might not be appropriate for finding a price effect after 1980.

Mendelsohn et al. find evidence that a negative price effect began in 1981, after some state and federal activities related to the discovery of hazardous waste, but before the site was proposed for (1982) or listed on (1983) the NPL (Mendelsohn, Hellerstein et al. 1992). This suggests the decline in home prices did not accompany placement on the NPL.

Kiel and Zabel (2001) find that houses near what later became an NPL site near Woburn, Massachusetts suffered no negative price effect during the 1970s while the facilities were operating. After contamination was discovered and the sites were closed down in 1979, a negative price effect quickly developed. This occurred before the sites were proposed for the NPL in 1982. A lengthy, high profile lawsuit took place over the course of the next several years during which these sites became very widely know. They were later the subject of the popular book and movie, *A Civil Action*. The results from Kiel and Zabel (2001) suggest the price effect fluctuated after discovery, seeming to rise with major events that might draw attention to the site (e.g., release of the ROD and the start of remedial action).

Reichert (1997) examines 17 years of data individually, and finds little evidence of a price effect from discovery (1980) through proposal (1984) and listing (1986). The price effect in this study appears during and after 1987, when the ROD is released. These results contradict much of the rest of the literature, but it is not clear why, although some prior knowledge of the existence of the landfill may explain this result.

Dale, Murdoch et al. (1999) find that the site they evaluate (the RSR lead smelter) had a negative effect on the prices of nearby homes while the facility was operating in the late 1970s, before CERCLA and the NPL. This site has a complex history and the nearby housing market may have received confusing signals. (More details about this site can be found in the RSR Smelter case study on page 4-21.) Most of the study period for Dale, Murdoch et al. (1999), and much of the response action, occurred before the site was proposed for the NPL. The site was first the subject of municipal and state lawsuits and then response actions. A Texas judge declared the site was clean and the negative price effect began to reverse. However, EPA subsequently discovered new problems at the site and changed the applicable health standard. Thus, the proposal to list this site on the NPL (1993) comes after the site had previously been declared cleaned up, so listing led to a return of the negative price effect. McCluskey and Rausser (2003a) evaluate the same site, but use a somewhat different data set and technique (repeat sales data) and also find that proximity to the site reduces appreciation in home prices (not prices, per se) in 1979-80, and that the effect varies after that period. Moreover, McCluskey and Rausser interpret their results to show that housing markets can take a significant period to adjust to new equilibrium conditions following the addition of new information. Subsequent research by McCluskey and Rausser (2003b), using data similar to Dale (1999), suggests a similar conclusion.

Unique among the studies reviewed here, McMillen and Thorsnes (2000) use nonparametric methods to examine the price effect of proximity to an NPL site (not in Table 4.2). They find a significant negative price effect while the site (a smelter in Tacoma, WA) was operating, which was well before NPL proposal or listing.

Unique among the studies in Table 4.2, Gayer, Hamilton et al. (2002) use no data prior to discovery; for all but one of the seven sites they examined, the sites had been listed several years (mean 4.5) before their data begins. They hypothesize that potential home buyers learn by incorporating new site-specific information from the media in their decision-making, and test this hypothesis by evaluating changes in the price effect due to proximity to NPL sites in the city of Grand Rapids, Michigan. Previous research had shown that these sites have relatively less cancer risk than do more typical NPL sites (Hamilton and Viscusi 1999a). Gayer et al. find support for their hypothesis in a reversal of the negative price effect over the period they study. However, their maximum estimate is from 1988, well after almost all of the sites had been listed. Hence, by that time the media could have already broadcast considerable information about the sites, and the price decline could have already occurred. This has no bearing on Gayer et al.'s conclusions, but it makes their data problematic for use here because it may not capture the total price effect, which may explain why Gayer et al. report the second lowest values for the negative price effect.

This evidence strongly suggests that discovery is the CERCLIS event that best corresponds to the event that initiates a decline in home prices near NPL sites.

Case Study: RSR Smelter

The smelting facilities of the RSR Smelter NPL site, cover 6.7 acres in west Dallas County, Texas, and are set amid residential, industrial, and commercial properties.[1] The processing of lead slag and scrap from batteries began in the 1930's. In the subsequent decades, lead emissions into the air contaminated much of the surrounding area, along with arsenic and cadmium. In addition, battery casing chips and slag were dumped in landfills and used as fill in residential areas, furthering the lead contamination in the area. By 1983, blood lead analyses showed that 90% of resident children under the age of six had blood lead levels (BLLs) greater than 10 µg/dL (micrograms per deciliter), the current level of concern set by ATSDR. There is a public housing complex adjacent to the former smelter, with 1,600 units occupied primarily by Black, low-income families. The neighborhoods surrounding RSR Smelter are predominantly Black and Hispanic.

The City of Dallas initiated legal actions against RSR Corp. in 1968, but it was only in 1984 that the smelter was successfully shut down and operations ceased. In 1982, prior to the closure of the smelter and the initial cleanup conducted by RSR, ATSDR tested blood lead levels (BLLs) in 227 randomly selected children under the age of six. The average BLL at that time was 20.1 µg/dL, well above the current health benchmark of 10 µg/dL. RSR Corp. agreed to clean up the contamination near the site beginning in 1983. However, this initial cleanup addressed only soils with lead content greater than 1000 parts per million (ppm) within half a mile of the smelter. In 1986, EPA confirmed completion of these cleanup activities, and later a Texas state judge found that the site was clean.

However, in 1991, in response to complaints from residents about slag piles remaining onsite, a new investigation of the site area was undertaken. Lead was found to still pose a health risk to residents, partly due to increased knowledge about the effects of lead and changes in the levels of lead considered safe. In 1993, RSR Smelter site was placed on the National Priorities List (NPL) and divided by EPA into five operable units (OUs). They are, in order of health risk:

1. OU1—residential areas (private residences) and recreational areas (greatest risk)
2. OU2—public housing complex
3. OU3—landfills and disposal areas for smelter wastes
4. OU4—actual smelter facilities
5. OU5—industrial facilities and the groundwater underlying the area (least risk)

To illustrate some key points about the Superfund program, two OUs at the RSR Smelter site will be discussed in detail: the relatively simple (but high-risk) OU1 and the more complex, more conventional OU4 (which presented far less current risk). The response actions illustrate the flexibility that CERCLA provides to address differences in health risk: OU1 was addressed entirely with a removal action while OU4 received a remedial action.

Almost immediately after discovery of the contamination, but well before the site was placed on the NPL, EPA and the Texas Natural Resource Conservation Commission (TNRCC) began to conduct further cleanups as removal actions under CERCLA. Together the TNRCC and EPA surveyed 6,800 potentially contaminated properties in OU1 and undertook cleanup at 420 private residences and other high-risk areas where children could be expected to play, including playgrounds, schools, and parks. This removal action included areas further from the smelter than considered in the previous cleanup, and all soils contaminated with lead greater than 500 ppm, arsenic greater than 20 ppm, or cadmium above 30 ppm were removed.

---

[1] Most of the information used to create this case study was obtained from various documents available on the Internet in July 2004, including: EPA's NPL Site Narrative for RSR Corp., May 1993, www.epa.gov/superfund/sites/npl/ nar1381.htm; ATSDR's Public Health Assessment of the RSR Smelter site, August 16, 1995, www.atsdr.cdc.gov/HAC/PHA/rsrcorp/rsr_toc.html; EPA's NPL Site Fact Sheet for RSR Corp., February 2004, www.epa.gov/earth1r6/6sf/pdffiles/rsr.pdf; EPA's ROD for the RSR Corporation site, February 1996, www.epa.gov/superfund/ sites/rods/fulltext/r0696099.pdf; as well as (Dale 1999) and (McCluskey and Rausser 2003a).

Case Study: RSR Smelter (continued)

The cleanups in the 1980s and early 1990s greatly reduced exposure. By 1993, blood lead analyses indicated that only 8% of children in the area exceeded 10 µg/dL, and blood lead level testing of 305 randomly-selected children showed an average BLL of 5.5 µg/dL. The population within 2.5 miles of this site was approximately 50,000, with over 7,000 children under the age of seven. Therefore, a considerable number of individuals vulnerable to lead-induced neuropsychological disorders were exposed.

After the removal action, OU1 no longer was contaminated above levels of concern, so no remedial action was necessary, so the ROD for OU1 declared the location to have “no further remedial action planned.” In August 1995, ATSDR determined that OU1 posed “no apparent public health hazard.” Importantly, because BLRAs were conducted only for the OUs that were listed (i.e. not OU1), they did not include residential portion of the site, which had been associated with the greatest health risk, because it had already been addressed by a removal action.

Operable unit 4 comprises the actual smelter facilities. Because there are no residents living in this area, cleanup of OU4 was less of a priority than cleanup of residential areas. To prevent human exposure to contaminants on the site prior to remedial action, OU4 was made inaccessible to the public using a barbed-wire topped fence and a 24-hour guard, relatively intrusive and expensive form of institutional control.

OU4 was addressed primarily through a conventional NPL remedial action. However, the investigation of the site revealed several actual or potential uncontrolled releases of hazardous substances, so in 1995 the sources of these releases were addressed with a removal action. This effort resulted in the removal of over 500 waste drums, 72 waste piles, and 50 laboratory containers and addressed immediate threats to human health and the environment, enabling the remedial process to continue. BLRAs for this site also not include the risk reduction accomplished by this removal, because they were not part of the residual risks that the BLRA was designed to address. Therefore, any assessments based on the ROD data for this site would not include these risks. The 1996 ROD for OU4 called for demolition of on-site structures and safe disposal of all building materials as well as all contaminated soil to a depth of 2 feet. This remedial action was completed in December 2001, paid for and conducted by seven of the parties potentially responsible for the site’s contamination, under a Consent Decree with EPA.

Dividing the site into multiple OUs and prioritizing threats posed by each allowed EPA to address risks at the RSR Smelter to protect human health in a timely manner in accordance with the relevant statutes. Using removal authorities to quickly reduce health risks to exposed populations, while restricting access to uninhabited areas until remedial actions could be devised and implemented, enabled EPA to protect human health without sacrificing the need for site study and careful remedial planning. It also illustrates that a benefits analysis based solely on information from BLRAs and RODs that includes only cancer risk reductions from remedial actions can overlook very substantial benefits from Superfund response actions.

Meta-analysis: Reversal

Compared to the studies that have looked for price declines experienced by homes near NPL sites, few studies have looked for possible reversals. In general, those that have seem to find mixed results, but at least some of the variation can be explained by examining the site history and data used in each study. Some studies, that show no reversal, simply do not have data for the periods during which a reversal might occur. Other studies, that show no reversal, report on sites with unusual and complex site histories. Those studies that examine sites with relatively typical site histories and have the data needed to observe a reversal tend to find one. The discussion below of the relevant studies is organized around these three groups.

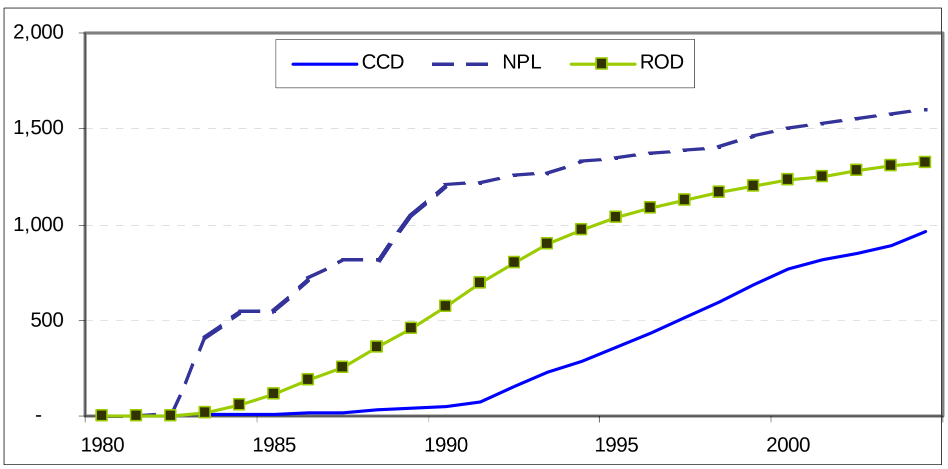
Several do not use data sets that cover events that might be expected to reverse the effect. McClelland (1990) finds no rebound, using data that was gathered before listing. Subsequently, Hurd (2002) compared McClelland's data from before listing to data after listing, ROD, and the start of the remedial action and finds a significant reversal of the negative price effect. Kohlhase (1991) does not find a rebound, using data that includes the listing of only three of seven sites and the ROD of only one.

Studies that have found no evidence of a reversal of the negative price effect, or a very delayed effect have evaluated somewhat unusual sites at which stigmatization has probably occurred, which would tend to make reversal of the price effect much slower (Gregory, Flynn et al. 1995; Kasperson, Jhaveri et al. 2001). Kiel and Zabel (2001) evaluate data that covers the period from before discovery through the beginning of remedial action, but shows no consistent reversal. However, this study evaluates the atypical Woburn, Massachusetts sites. The site evaluated by Dale et al. (1999) and McCluskey and Rausser (2003a, 2003b) had a very complex, atypical history. This site was declared clean by a Texas state court but EPA later found it to still be contaminated, leading to further response and listing on the NPL. This reversal in status appears to fit the critical requirement to create stigma; a violation or overturning of a standard of what is right and a discrediting (here of environmental regulators as well as the site). McCluskey and Rausser show theoretically that both stigmatized and non-stigmatized equilibrium outcomes are possible and find evidence of such an effect, but within a relatively limited distance (1.2 miles) of the site. Both groups of researchers conclude that information is more important to housing prices than response actions, but they differ as to whether or where a reversal occurred and whether stigma was involved. The same is true of a more recent study that also looked at Woburn, as well as three other sites with very long, contentious histories, and found little or only partial reversal of the negative price effect (Schulze, Messer et al. 2004).

Studies that examined more typical NPL sites and included data from appropriate time periods find clear evidence of reversal of the negative price effect between listing and the time the RODs are announced. McMillen and Thorsnes (2000) evaluate data that stretches from before discovery until well after remedial action had begun. They find that at about the time the site was listed, the negative price effect began to disappear. Further, they find this location subsequently gained an additional value over time after the smelter closed and the remedial action had proceeded. This seems to suggest there can be both an instantaneous and long-term reversals from the negative price effect that begin after listing. Gayer et al. (2003) find evidence of reversal occurring throughout the period they examined. Their study period began (with a small exception) after the seven sites had been listed and included the announcement of the ROD but (with one exception) did not include the start of remedial action. They find the release of the Remedial Investigation / Feasibility Study (RI/FS) (which occurs during the ROD process) is a key event in providing information to housing markets, initiating the reversal of the negative price effect of proximity to an NPL site.

Thus, there is evidence that some homes near NPL sites begin to experience a reversal of the decline in price associated with proximity to the NPL site after the site is listed and before the remedial action is complete, with the possible exception of sites with very complex histories. The release of information is very important to this process and the single most important informational event is the release of the ROD. Therefore, the release of RODs is used in the current study to count the number of sites to which benefits are transferred. For most NPL sites, this occurs about halfway between the Listing and the end of remedial action as shown in Chapter 3 of Probst and Konisky (2001) and in Figure 4.7. This Figure shows the cumulative numbers of sites: i) that were proposed, final, or deleted from the NPL (NPL); ii) for which RODs have been published (ROD); or, iii) for which remedial action is essentially complete (construction complete or deleted, CCD).[8] The year the ROD is published is a rough approximation of when most of the benefits of NPL remedial action occur (as measured by changes in home prices), and the value of the remedial action is capitalized immediately at that point. The benefits transfer analysis below assumes that this approach ignores the possibility of stigma and other issues associated with heterogeneity among NPL sites, which should be explored in further research. However, it appears that stigmatization occurs at a relatively small number of often highly visible NPL sites, so this simplification is not likely to introduce substantial error.

Figure 4.7. Sites in the NPL Pipeline



Note: NPL values are the number of sites that are Proposed, Final, or Deleted from the NPL; ROD values are the number of sites for which a Record Of Decision has been issued; CCD values are the number of sites that have reached Construction Complete or Deleted status.

[8] While no sites were proposed to the NPL before 1982, CERCLIS reports a small number of RODs in 1980-81, which were created for sites that EPA had begun working on under other authority before Superfund was created.

Benefits Transfer Analysis

Most of the values required have now been determined, including the measures of central tendency that will be transferred to homes near NPL, the number of NPL sites to which this applies, and the timing of these transfers. The last value that needs to be determined is the number of homes to which to transfer the benefit. Due to the limitations of the data and to avoid double-counting (see Chapter 3), the entire benefits transfer for all NPL sites that have had RODs issued are calculated, and then distributed over time in proportion to the number of sites, assuming all sites are similar to the average.

The U.S. Census data at the census block group level is used to estimate the number of number of residences near NPL sites, where "near" is defined as on the site or within 1, 2.5, or 4 miles of the site boundary. Because actual site boundary data are not available, sites are modeled as circles, using the site location data in EPA's CERCLIS database as the center of the circle and the area of the site to determine the radius of the circle. Following the convention in the literature, any effect of being near more than one site is ignored. Thus, for all calculations, residences are associated with the NPL site they are closest to, and counted only once. Residences are placed into one of 6 distance bins: <0.5 miles from the site boundary (including onsite), 0.5-1.0 miles from the site, 1.0-1.5 miles from the site, 1.5-2.0 miles from the site, 2.0-2.5 miles from the site, and 2.5-4.0 miles from the site. (See Chapter 3 for more information on how the data were treated.)

The four measures of central tendency presented above each require a slightly different method for transfer to the policy case, as shown in the four models in Equations 4.2, 4.3, 4.4, and 4.5.

$$B_r^{LA} = LE \times R_r$$ Linear Absolute (LA) model (Equation 4.2)

$$B_r^{LP} = LPE \times P_r \times R_r$$ Linear Percentage (LP) model (Equation 4.3)

$$B_r^{NLA} = \sum_i \left(NE_i \times R_{i,r} \right)$$ Non-Linear Absolute (NLA) model (Equation 4.4)

$$B_r^{NLP} = \sum_i \left(NPE_i \times P_r \times R_{i,r} \right)$$ Non-Linear Percentage (NLP) model (Equation 4.5)

where,

B_r^X = the benefit of the remedial actions at NPL sites that have had RODs issued from 1980-2004 using model X (i.e., LA, LP, NLA, or NLP) and assuming the negative price effect extends to r miles from the site and the reversal of the negative price effect is complete

R_r = the number of residences within distance r of any NPL site that has had a ROD issued

$R_{i,r}$ = the number of residences in bin i within distance r of any NPL site that has had a ROD issued

LE = the linear absolute price effect of proximity to an NPL site on home prices

NE_i = the non-linear absolute price effect of proximity to an NPL site on home prices

LPE = the linear percentage price effect of proximity to an NPL site on home prices

NPE_i = the non-linear percentage price effect of proximity to an NPL site on home prices

P_r = the mean of census block group median home prices for all census block groups within distance r of an NPL site, weighted by the number of homes per census block group
$P_{i,r}$ = the average of census block group median home prices for all census block groups in bin i, weighted by the number of homes per census block group
For r = 1, 2.5, or 4 and for bins i = <0.5, 0.5-1.0, 1.0-1.5, 1.5-2.0, 2.0-2.5, 2.5-4.

In equations 4.2 and 4.3, the linear models, the per-home benefits are simply multiplied by the number of residences on or within distance r of all NPL sites. Similarly, in equations 4.4 and 4.5, the number of residences is disaggregated into a set of distance bins. Equations 4.2 and 4.4 use the absolute models, the estimate of the absolute effect in dollars. In Equations 4.3 and 4.5, the percentage models, the product of the percentage effect and median home prices (by census block group) is used. Note that these models are linear in all parameters except for maximum distance from the site boundary, r, simplifying sensitivity analysis.

The estimates for benefits found with these models are the undiscounted sums of the WTP for remedial actions at all NPL sites that have had RODs issued for them, for all residences using the mean benefits shown in Tables 4.4 and 4.5. An economic meaning cannot be inferred until this total benefit is distributed over time and discounted.

The determination of the annual (undiscounted) benefit ($AB_{r,t}^X$) is shown in Equation 4.6. Total benefit for distance r in year t is scaled by the ratio of NPL sites that have RODS issued that year to the total through 2004 (1,326) and a population growth factor (PGF_t). The population growth factor accounts for changes in population before and after 2000, which is the census year used to calculate the number of residences, R_r and $R_{i,r}$. In census block groups near NPL sites, population increased 7.7% from 1990 to 2000, which implies an average annual growth rate of 0.745%. The PGF_t simply accounts for this effect on an annual basis.

$$AB_{r,t}^X = B_r^X \times \frac{ROD_t}{1326} \times PGF_t \qquad \text{(Equation 4.6)}$$

These steps yield a stream of annual benefits for 1980-2004 in 2000$ for each of the four models given above, which is discounted at a 7% rate to yield present values in 1980.[9,10] Two sensitivity analyses were conducted. The first assumes that the price effects for non-SOD homes are only one half of those for SOD homes. This reduces the benefit by about one quarter. The second re-calculates the benefit assuming that the effect extends to 1 mile and to 4 miles.

[9] The present value of a series of benefits (or costs) that occur in the future (in this case, annually) is equal to the sum of the individual benefits (or costs) discounted into present-day terms. The equation for discounting is $PV = B \big/ (1+r)^t$ where B is the benefit, r is the discount rate, and t is the number of years in the future. The conceptual framework for discounting is based on the fact that present consumption is valued more than future consumption. Appropriate discount rates for analyses such as the one presented here include 3% and 7% (U.S. Environmental Protection Agency 2000 Chapter 6).

[10] For alternative base-year discounting see Appendix C of the current study.

Results and Discussion

The present values of this benefits transfer analysis are shown below in Tables 4.6 and 4.7 and Figure 4.8, along with 95% confidence intervals. Values for discount rates of 3% and 7% are given. For convenience, only the 3% values are discussed here. The mean values for the four models range from $63-$100 billion over the period 1980-2004. The 95% confidence intervals range from a low of $41 billion to a high of $130 billion. Each of the four models and the data used to estimate the parameters in each (specifically, the magnitude of the price effect) has different advantages and disadvantages. The Linear Absolute (LA) model has the largest amount of data associated with it, but it is the least theoretically appealing model. On the other hand, the most theoretically appealing model, the Non-Linear Percentage (NLP) model is supported by only a few studies. The issue thus becomes, partly, which provides a greater improvement over the LA model, using a percentage-based model or using a non-linear model? Given the close agreement of the absolute and percentage models, using a non-linear model probably provides more advantage. Considering both functional form and data quality, the results that are probably the most reliable come from the Non-Linear Absolute (NLA) model. Thus, the best point estimate of the present value (1980, r=3% in 2000$) of the benefits of NPL remedial actions for the first 25 years of the Superfund program appears to be about $63 billion.

These calculations are fairly sensitive to the maximum distance at which the price effect is assumed to operate. If this effect is only one mile, the benefit drops by 70%, if it extends all the way out to 4 miles, the benefit may be twice as large as the values shown in Figure 4.6. Note that only one of the studies in Table 4.2 found a non-linear effect extending past 3 miles, so non-linear results for 4 miles were not calculated. These calculations are less sensitive to assumptions about the price effect for non-single family, owner-occupied, detached (SOD) residences. If non-SOD homes experience only half the effect of SOD homes (for which there is no evidence), mean estimates of the benefits range from about $47-$77 billion.

Table 4.6 also presents annualized values of these benefits, which are another way (in addition to present values) of expressing the magnitude of benefits that vary across time. An annualized benefit is the size of a fixed annual benefit, which, if it occurred at the end of each year and was discounted back to the base year (1980, in this case) would result in the same present value as the actual series of benefits. Thus, calculating an annualized benefit converts a series of unequal benefits to a series of uniform benefits, both of which have the same present value. The annualized benefits of NPL remedial actions, using the assumptions and methods given above, range from $3.6-$5.9 billion per year over the period 1980-2004, depending on the model used and assuming a 3% discount rate. The 95% confidence interval is $2.4-$7.4 billion per year.

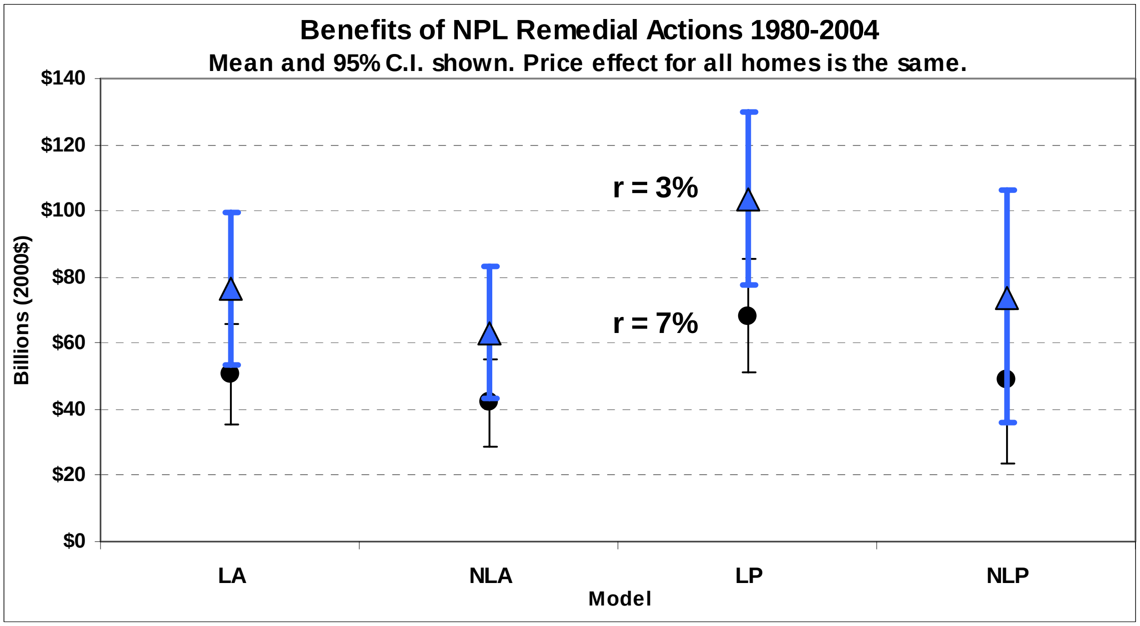
Table 4.6. Present Value of the Benefits of NPL Remedial Actions, 1980-2004
(Billion 2000$, Base year 1980)

Discount rate = 7%	Value	Model			
All residence types equivalent		LA	NLA	LP	NLP
Max distance 2.5 mi.	Mean	50	42	68	49
	95% CI	35-66	29-55	51-85	27-74
50% effect for Non SOD homes	Mean	38	31	51	36
Max distance 1 mi.	Mean	14	-	-	-
Max distance 4 mi.	Mean	94	-	-	-
Discount rate = 3%	**Value**	**Model**			
All residence types equivalent		LA	NLA	LP	NLP
Max distance 2.5 mi.	Mean	77	63	100	74
	95% CI	53-100	43-83	77-130	41-110
50% effect for Non SOD homes	Mean	57	47	77	55
Max distance 1 mi.	Mean	22	-	-	-
Max distance 4 mi.	Mean	140	-	-	-

Table 4.7. Annualized Value of the Benefits of NPL Remedial Actions, 1980-2004
(Billion 2000$, Base year 1980)

r = 7%	Value	Model			
All residence types equivalent		LA	NLA	LP	NLP
Max distance 2.5 mi.	Mean	4.3	3.6	5.8	4.2
	95% CI	3.0-5.6	2.5-4.7	4.3-7.3	2.3-6.3
r = 3%	**Value**	**Model**			
All residence types equivalent		LA	NLA	LP	NLP
Max distance 2.5 mi.	Mean	4.4	3.6	5.9	4.2
	95% CI	3.1-5.7	2.5-4.8	4.4-7.4	2.4-6.4

Figure 4.8. Present Value of the Benefits of NPL Site Remedial Activities, 1980-2004
(Billion 2000$, Base year 1980, 2.5 miles)



However, there are four major limitations to these results.

First, this analysis includes perceived risks and uncertainty, as measured by WTP in housing markets, as well as actual risks, so is not directly comparable to some previous analyses (Hamilton and Viscusi 1999b).

Second, this analysis also ignores many benefits (as do other studies). For instance, because removal actions at NPL sites may be largely ignored by the media and the public and appear to be ignored by housing markets, most of the real health risk reduction that occurs at NPL sites is probably not captured by home prices. In addition, benefits accruing to non-neighbors, including preserving ground water for safe human and non-human use in the future and restoring of land to productive use or ecological health, are not captured here.

Third, this analysis also ignores heterogeneity across NPL sites. Thus, while the approach suggests that, in aggregate, NPL remedial actions have significant benefits, this is almost certainly not true of each individual remedial action. Previous analysis shows that actual and perceived risks vary greatly across sites, and may be concentrated at a small number of sites (Hamilton and Viscusi 1999a). One of the most important aspects of site heterogeneity may be whether or not a site is stigmatized because property values at sites where stigmatization occurs may not recover quickly (Kunreuther and Slovic 2001; McCluskey and Rausser 2003b; Schulze, Messer et al. 2004).

Fourth, this data is retrospective only and may have limited applicability in thinking about the future of the Superfund program or of managing hazardous substances more generally. Most of the data used by the studies considered in the meta-analysis come largely from before 1990. Thus, it reflects site characteristics, EPA procedures, and remedial technologies that are somewhat different from those today and those expected in the future (Probst and Konisky 2001 Ch. 5).

References

Anonymous (2000). Raising the Roof- California Housing Development Projections and Constraints 1997-2020. Sacramento, CA, California Business, Transportation and Housing Agency.

Bartik, T. J. (1988). "Measuring the Benefits of Amenity Improvements in Hedonic Price Models." Land Economics **64**(2): 172-183.

Boyle, K. J. (2003). Introduction To Revealed Preference Methods. A Primer on Nonmarket Valuation. P. A. Champ, K. J. Boyle and T. C. Brown. Boston, Kluwer Academic Publishers**:** 259-267.

Boyle, M. A. and K. A. Kiel (2001). "A Survey of House Price Hedonic Studies of the Impact of Environmental Externalities." Journal of Real Estate Literature **9**(2): 117-144.

Cameron, T. and G. D. Crawford (2003). Superfund Taint and Neighborhood Change: Ethnicity, Age Distributions, and Household Structure. University of Oregon Economics Department Working Papers. Eugene**:** 28.

Dale, L., J. C. Murdoch, et al. (1999). "Do property values rebound from environmental stigmas? Evidence from Dallas." Land Economics **75**(2): 311-326.

EPA Science Advisory Board (2002). Underground Storage Tanks (UST) Cleanup & Resource Conservation & Recovery Act (RCRA) Subtitle C Program Benefits, Costs, & Impacts (BCI) Assessments: An SAB Advisory. Washington, DC, USEPA**:** 50.

Freeman, A. M. (1993). The Measurement of Environmental and Resource Values: Theory and Methods. Washington, DC, Resources For the Future.

Gayer, T., J. T. Hamilton, et al. (2000). "Private values of risk tradeoffs at superfund sites: Housing market evidence on learning about risk." Review of Economics and Statistics **82**(3): 439-451.

Gayer, T., J. T. Hamilton, et al. (2002). "The market value of reducing cancer risk: Hedonic housing prices with changing information." Southern Economic Journal **69**(2): 266-289.

Gayer, T. and W. K. Viscusi (2002). "Housing Price Responses to Newspaper Publicity of Hazardous Waste Sites." Resource & Energy Economics **24**(1): 33-51.

Gregory, R., J. Flynn, et al. (1995). "Technological Stigma." American Scientist **83**(3): 220-3.

Gregory, R. S. and T. A. Satterfield (2002). "Beyond perception: The experience of risk and stigma in community contexts." Risk Analysis **22**(2): 347-358.

Harrison, R. M. (2003). "Hazardous waste landfill sites and congenital anomalies: Where do we go from here?" Occupational and Environmental Medicine **60**(2): 79-80.

Hird, J. A. (1994). Superfund : the political economy of environmental risk. Baltimore, Johns Hopkins University Press.

Hite, D. (1998). "Information and bargaining in markets for environmental quality." Land Economics **74**(3): 303-316.

Hite, D., W. Chern, et al. (2001). "Property-value impacts of an environmental disamenity: The case of landfills." Journal of Real Estate Finance and Economics **22**(2-3): 185-202.

Hurd, B. H. (2002). "Valuing superfund site cleanup: Evidence of recovering stigmatized property values." The Appraisal Journal **70**(4): 426-437.

Ihlanfeldt, K. R. and L. O. Taylor (2004). "Externality effects of small-scale hazardous waste sites: evidence from urban commercial property markets." Journal of Environmental Economics and Management **47**: 117-139.

Johnson, B. L. (1999). Impact of hazardous waste on human health : hazard, health effects, equity, and communications issues. Boca Raton, Lewis Publishers.

Kasperson, R. E., N. Jhaveri, et al. (2001). Stigma and the Social Amplification of Risk. Risk, Media, and Stigma. J. Flynn, P. Slovic and H. Kunreuther. Sterling, VA, Earthscan**:** 9-27.

Kiel, K. and J. Zabel (2001). "Estimating the economic benefits of cleaning up Superfund sites: The case of Woburn, Massachusetts." Journal of Real Estate Finance and Economics **22**(2-3): 163-184.

Kiel, K. A. and K. T. McClain (1996). "House price recovery and stigma after a failed siting." Applied Economics **28**(11): 1351-1358.

Kohlhase, J. E. (1991). "The Impact of Toxic-Waste Sites on Housing Values." Journal of Urban Economics **30**(1): 1-26.

Kunreuther, H. and P. Slovic (2001). Coping with Stigma: Challenges and Opportunities. Risk, Media and Stigma. J. Flynn, P. Slovic and H. Kunreuther. Sterling, VA, Earthscan**:** 331-352.

Lipscomb, J. A., L. R. Goldman, et al. (1992). "A study of current residents' knowledge of a former environmental health survey of their community." Archives of Environmental Health **47**(4): 270-4.

McClelland, G. H., W. D. Schulze, et al. (1990). "The Effect of Risk Beliefs on Property Values: A Case Study of a Hazardous Waste Site." Risk Analysis **10**(4): 485-97.

McCluskey, J. J. and G. C. Rausser (2001). "Estimation of perceived risk and its effect on property values." Land Economics **77**(1): 42-55.

McCluskey, J. J. and G. C. Rausser (2003). "Hazardous waste sites and housing appreciation rates." Journal of Environmental Economics and Management **45**(2): 166-176.

McCluskey, J. J. and G. C. Rausser (2003). "Stigmatized Asset Value: Is It Temporary Or Long-Term?" Review of Economics and Statistics **85**(2): 276-285.

McConnell, K. E. (1993). Indirect Methods for Assessing Natural Resource Damages Under CERCLA. Valuing Natural Assets: The Economics of Natural Resource Damage Assessment. R. J. Kopp and V. K. Smith. Washington, DC, Resources For the Future**:** 153-203.

McMillen, D. P. (2003). "The aroma of Tacoma: Time varying average derivatives and the effect of a superfund site on house prices." Journal of Business & Economic Statistics **21**(2): 237-246.

McMillen, D. P. and P. Thorsnes (2000). The reaction of housing prices to information on superfund sites: A semiparametric analysis of the Tacoma, Washington market. Advances in Econometrics, Vol 14. **14:** 201-228.

Mendelsohn, R., D. Hellerstein, et al. (1992). "Measuring Hazardous-Waste Damages with Panel Models." Journal of Environmental Economics and Management **22**(3): 259-271.

Michaels, R. G. and V. K. Smith (1990). "Market-Segmentation And Valuing Amenities With Hedonic Models - The Case Of Hazardous-Waste Sites." Journal of Urban Economics **28**(2): 223-242.

Nelson, A. C., J. Genereux, et al. (1997). "Price effects of landfills on different house value strata." Journal of Urban Planning and Development-ASCE **123**(3): 59-67.

Office of Technology Assessment (1989). Coming Clean: Superfund Problems Can Be Solved. Washington, DC, U.S. Congress**:** 223.

Palmquist, R. B. (1991). Hedonic Methods. Measuring the Demand for Environmental Quality. J. Braden and C. Kolstad. Amsterdam, Elsevier Science**:** xxx-xxx.

Palmquist, R. B. (1992). "A Note on Transactions Costs, Moving Costs, and Benefit Measurement." Journal of Urban Economics **32**(1): 40-44.

Palmquist, R. B. (1992). "Valuing Localized Externalities." Journal of Urban Economics **31**(1): 59-68.

Probst, K. N. and D. M. Konisky (2001). Superfund's Future: What Will It Cost? Washington, DC, RFF Press.

Reichert, A. K. (1997). "Impact of a toxic waste Superfund site on property values." The Appraisal Journal **65**(4): 381-392.

Rosen, S. (1974). "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition." Journal of Political Economics **82**(Jan/Feb): 34-55.

Rosenberger, R. S. and J. B. Loomis (2003). Benefit Transfer. A Primer on Non-Market Valuation. P. A. Champ, K. J. Boyle and T. C. Brown. Boston, Kluwer Academic Press**:** 445-482.

Schulze, W. D., K. Messer, et al. (2004). Stigma: The Psychology and Economics of Superfund. Washington, DC, U.S. Environmental Protection Agency**:** 228.

Slovic, P., B. Fischhoff, et al. (1979). "Rating the Risks." Environment **21**(3): 14-20, 36-39.

Smith, V. K. and W. H. Desvousges (1986). "The Value of Avoiding a LULU - Hazardous-Waste Disposal Sites." Review of Economics and Statistics **68**(2): 293-299.

Thayer, M., H. Albers, et al. (1991). "The Benefits of Reducing Exposure to Waste Disposal Sites: A Hedonic Housing Value Approach." The Journal of Real Estate Research **7**(3): 265-281.

U.S. Environmental Protection Agency (1987). Unfinished business : a comparative assessment of environmental problems (Volume 1 - Overview). Washington, DC**:** 120.

U.S. Environmental Protection Agency (2000). Guidelines For Preparing Economic Analyses. Washington, DC**:** 210.

Viscusi, W. K., J. T. Hamilton, et al. (1997). "Conservative versus mean risk assessments: Implications for superfund policies." Journal of Environmental Economics and Management **34**(3): 187-206.

Walker, K. D., M. Sadowitz, et al. (1995). Confronting Superfund Mythology: The Case of Risk Assessment and Management. Analyzing Superfund: Economics, Science and Law. R. L. Revesz and R. B. Stewart. Washington, DC, RFF Press**:** 25-53.

This Page Intentionally Left Blank